SAPHEA
INTEGRATING GEOTHERMAL HEATING AND COOLING NETWORKS IN EUROPE

Deliverable D3.2 – Open-source toolbox for early-stage investment decision support and strategic planning

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SAPHEA Toolbox: GeoDHC Decision Support System

Overview

The SAPHEA Toolbox is a digital decision-support tool designed to accelerate the adoption of geothermal energy in multivalent district heating and cooling (DHC) networks across Europe. It brings together data, evaluation routines, and planning tools into one easy-to-use platform. The toolbox provides visualisation of the data layers and technical analysis through several calculation modules (CMs) and is available at: https://toolbox-saphea.eu/.

Core Features

1. Pan-European Data Visualisation

- Pan-European geothermal datasets collected within the scope of WP2 are integrated into the SAPHEA Toolbox. These data layers span across Europe, including cities with geothermal DHC, heat flow densities, subsurface temperatures, etc, are visualised under the "Layers" tab, "Geothermal" category.

2. Techno-Economic Calculation Modules

- **SAPHEA-GEOPHIRES CM**: This module leverages the GEOPHIRES open-source model for early-stage hydro-geothermal assessment. It estimates key metrics such as heat production, drilling and completion costs, pump energy, and Levelised Cost of Heat (LCOH). Inputs include reservoir and well data, along with optional operational and cost-adjustment parameters. Outputs consist of easy-to-screen platform indicators and exportable reports (.txt, .xlsx).
- **LS-GEOHP CM**: Designed to model integration of geothermal heat pumps with medium/deep geothermal sources, this module calculates thermal output, Coefficient of Performance (COP), electricity consumption, and heat pump investment costs under various scenarios (direct use, capacity increase, temperature boost). It uses user inputs related to geothermal brine flow rate, temperatures, and district heating network conditions. The tool is accessible from both the SAPHEA toolbox and as a standalone HTML file.
- **District Heating Potential Areas (User-Defined Thresholds) CM**: This module identifies potential district heating zones based on heat demand density by applying two user-defined thresholds: minimum demand per hectare and minimum annual demand per contiguous area. Users can visualise potential DH areas on the map and review summary indicators such as total heat demand, DH potential, and area-specific DH potential. The module includes options to import custom raster layers and adjust thresholds to reflect local conditions.
- **District Heating Potential: Economic Assessment CM**: Building on the potential areas module, this tool performs a simplified economic analysis of district heating networks, combining heat demand and building density with distribution cost thresholds. It calculates GIS layers illustrating zones that meet cost-effectiveness criteria, estimates network infrastructure requirements (length, pipe diameter), and provides economic indicators such as capital costs and connection rates.
- **District Heating Supply CM**: This module simulates the levelised cost of heat (LCOH) for a range of supply technologies based on heat load profiles and several techno-economic parameters. A dispatch and investment optimisation model that determines the cost-minimal operational strategy for heat networks on an hourly basis. In dispatch mode, it optimises generation portfolios for hourly demand coverage and cost minimisation. In invest mode, it identifies optimal capacities for heating units and storage. Outputs include generation costs, technology mixes, CO_2 emissions, and full-load hours—providing valuable insights for network design and operation.

3. GIS-Enhanced Workflows

- Built on the Hotmaps framework, the toolbox supports combined raster and vector mapping, regional selection (NUTS, LAU, or manual polygons), and layered visualization of results. This feature is specifically used for the District Heating and Cooling calculation modules. Geothermal calculation modules work with point data, as pan-European data is not available for these calculation modules.
- Outputs of the calculation modules with GIS-based inputs are returned both as map layers (e.g., thermal supply potential) and Indicator dashboards**,** facilitating rapid spatial and quantitative assessment.

4. Open-Source, Transparent, and Accessible

- The toolbox is built entirely on open-source software, with code repositories and wiki documentation publicly accessible.
- The system runs on robust spatial backend infrastructure (PostGIS, GeoServer), and developers maintain active version control via Tuleap (“main” & “develop” branches).
- The platform is fully online and freely accessible at: https://toolbox-saphea.eu/.
- The wiki pages explain the technical background, required inputs and provided outputs in great detail. The wiki pages of the CMs also demonstrate a sample run with detailed instructions and screenshots. Table 1 includes all the related links to the wiki pages and code repositories.

Table 1: Links to the Wiki pages and open-source code repositories.

Component	Wiki Page	Open-Source Code Repository
SAPHEA Toolbox	https://saphea-project.github.io/wiki/welcome-to-saphea/	https://vlhtuleap.hevs.ch/plugins/git/git-eranet/Visualization_tool
SAPHEA GEOPHIRES CM	https://saphea-project.github.io/wiki/cm-geophires/	https://vlhtuleap.hevs.ch/plugins/git/saphea/saphea_geophires?a=tree&hb=main
LSGEOHP CM	https://saphea-project.github.io/wiki/cm-large-scale-geothermal-heat-pump/	https://vlhtuleap.hevs.ch/plugins/git/saphea/lsgeohp?a=tree&hb=main
District Heating Potential Areas (User-Defined Thresholds) CM	https://saphea-project.github.io/wiki/cm-district-heating-potential-areas/	https://vlhtuleap.hevs.ch/plugins/git/git-eranet/dh_potential?a=tree&hb=main
District Heating Potential: Economic Assessment CM	https://saphea-project.github.io/wiki/cm-district-heating-economic-assessment/	https://vlhtuleap.hevs.ch/plugins/git/git-eranet/dh_economic_assessment
District Heating Supply CM	https://saphea-project.github.io/wiki/cm-district-heating-supply/	https://vlhtuleap.hevs.ch/plugins/git/git-eranet/dispatch_module?a=tree&hb=main

Applications and User Benefits

- **For planners and energy utilities**: Enables early-stage screening of geothermal options, streamlines investment insights, and supports EU-wide comparative assessment.
- **For national/regional authorities**: Facilitates assessment of policy and infrastructure potential across administrative scales.
- **For researchers and developers**: Provides transparent, reproducible, and modular techno-economic modelling rooted in open-source methodologies.

How to Get Started

- Launch the toolbox online and select a region of interest within Europe (or import your data).
- Choose your Calculation Module, enter the required technical and economic parameters, then run the simulation.
- Visualise outputs on the map, export indicator charts, and retrieve detailed reports (CSV, Excel, or TXT).
- Explore wiki tutorials and source code via the official SAPHEA documentation portals.

1. User Interface & Navigation

The toolbox interface is intuitive and GIS-centric, providing a clean layout for spatial selection and module execution.

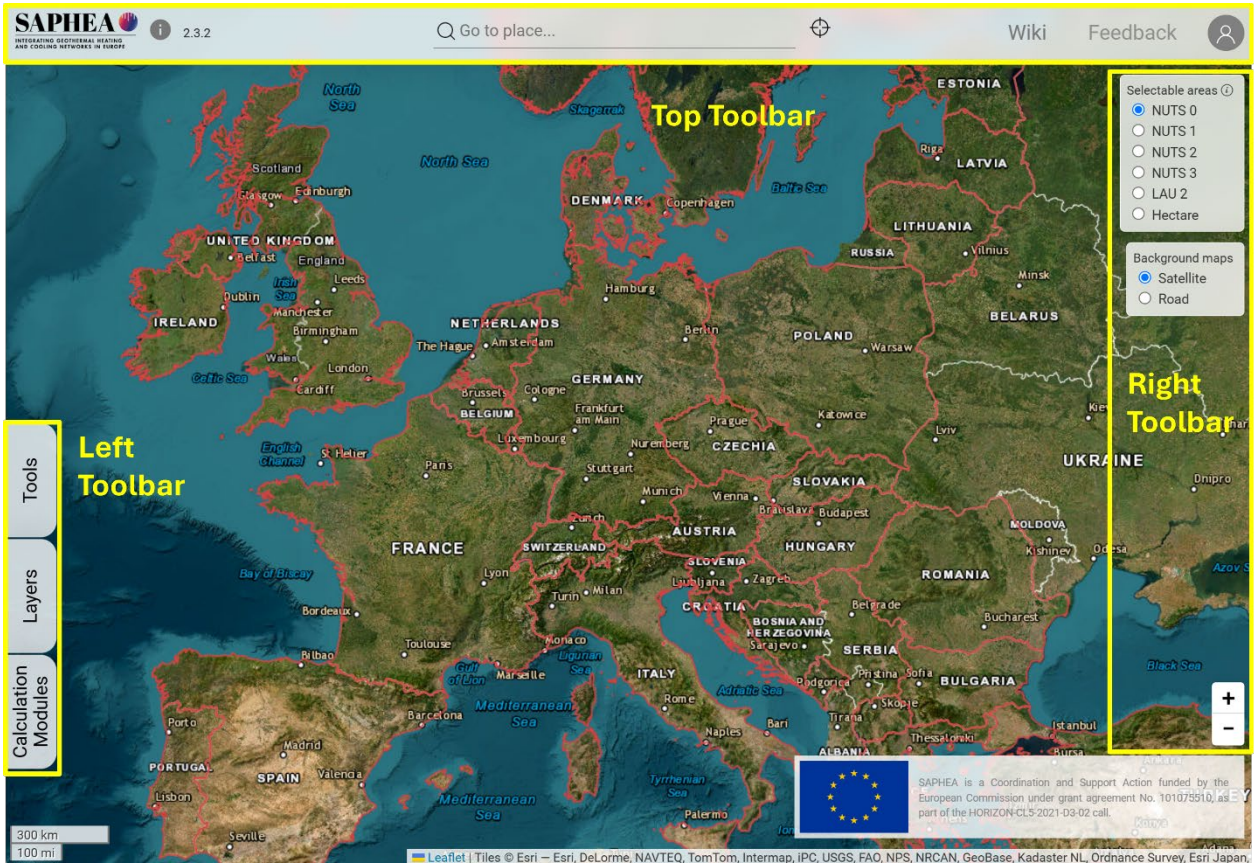

Figure 1: Web-based GIS interface with layer list and session controls.

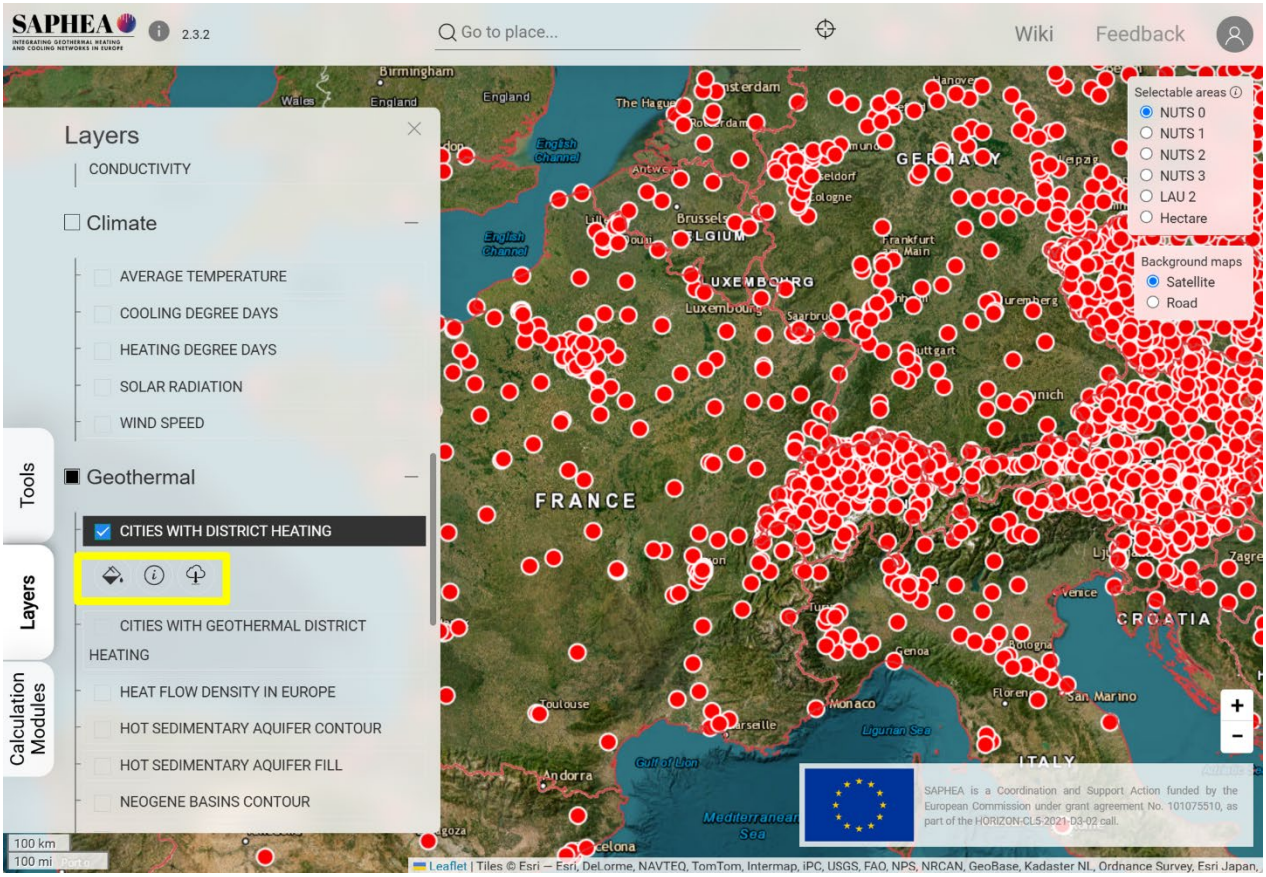

Figure 2: Region selector and visualisation of pan-European data layers.

2. Core Functionality & Workflow

Users follow a consistent workflow: select region → choose CM → set inputs → run simulation → export results.

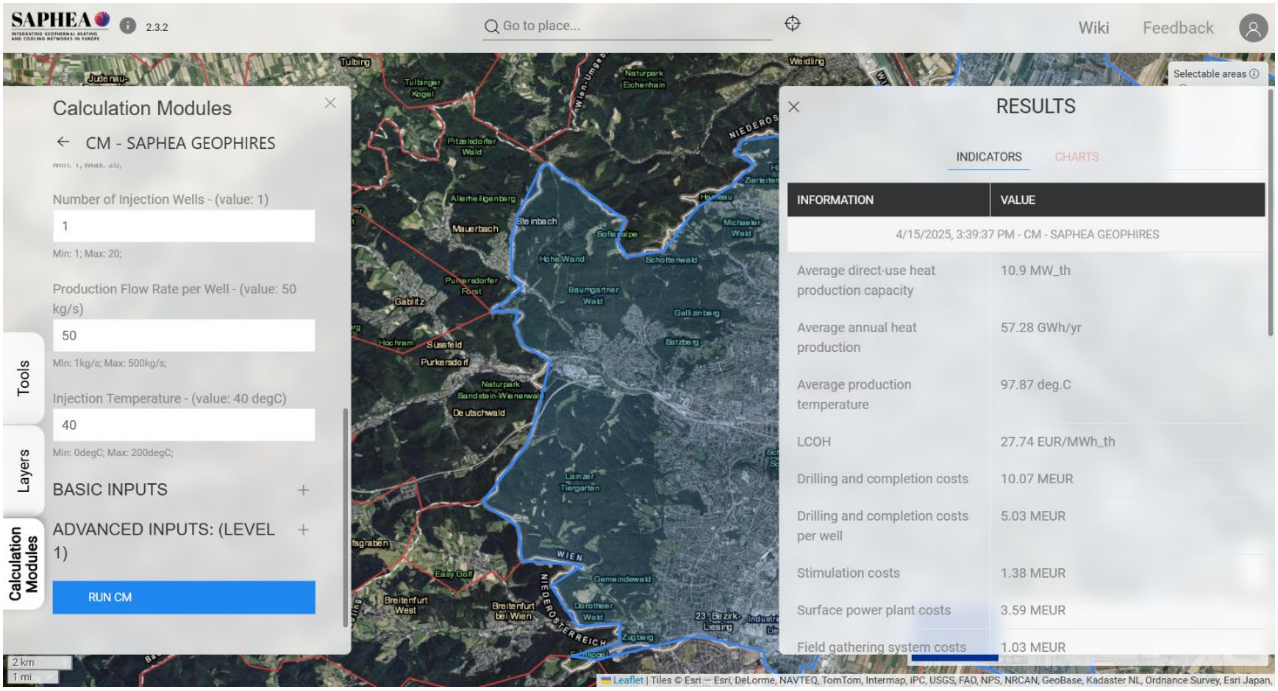

Figure 3: Core workflow navigation for selecting and running Calculation Modules.